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(54) **SYSTEM AND METHOD FOR PERFORMING SURGICAL PROCEDURE USING DRILL GUIDE AND ROBOTIC DEVICE OPERABLE IN MULTIPLE MODES**

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(58) **Field of Classification Search**
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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,747,393 A 5/1988 Medwid
4,903,536 A 2/1990 Salisbury, Jr. et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 1059067 A1 12/2000
EP 1184684 A2 3/2002
(Continued)

OTHER PUBLICATIONS

Meggiolaro, et al., "Manipulator calibration using a single endpoint contact constraint," in 26th ASME Biennial Mechanisms Conference, (Baltimore, MD), 2000.
(Continued)

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(57) **ABSTRACT**

System and method for performing a surgical procedure using a drill guide and a robotic device operable in multiple modes. The drill guide is mechanically coupled to the robotic device. A pre-defined virtual trajectory constrains movement of the drill guide. In a first mode, a user is able to manually manipulate the drill guide while movement of the drill guide is constrained by the pre-defined virtual trajectory. In a second mode, the robotic device operates autonomously, for instance, to perform service on the robotic device.

20 Claims, 13 Drawing Sheets